

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

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For : METHOD OF ETCHING STRUCTURES INTO AN  
ETCHING BODY USING A PLASMA  
Examiner : Shamim Ahmed  
Art Unit : 1792  
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Signature: /Kevin Kambo/  
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**REPLY UNDER 37 C.F.R. § 1.116**

S I R:

This paper is filed in response to the Final Office Action of January 19, 2010, for which the three-month response date expires on April 19, 2010, in connection with the above-captioned application.

Amendments to the Claims are not presented in this paper. Nonetheless, a **Listing of Claims** begins on page 2 of this paper for the convenience of the Office.

**Remarks** begin on page 7 of this paper.

While no fees are believed to be due, the Commissioner is authorized, as appropriate and/or necessary, to charge any fees or credit any overpayment to **Deposit Account No. 11-0600**.

**LISTING OF CLAIMS:**

1. (Previously Presented) A method of etching a structure into an etching body using a plasma, comprising:

injecting a high-frequency power into the etching body via a substrate electrode; and

refraining from injecting the high-frequency power into the etching body via the substrate electrode in response to an at least approximately ambipolar plasma being present.

2. (Original) The method as recited in Claim 1, wherein:

the etching body includes a silicon body,

the structure is a recess in the silicon body that is laterally defined in a precise manner by an etching mask, using the plasma,

a high-frequency pulsed, low-frequency modulated high-frequency power is injected at least temporarily into the etching body via a high-frequency AC voltage, using the substrate electrode, and

the plasma is modulated in its intensity as a function of time.

3. (Original) The method as recited in Claim 2,

wherein: the plasma is pulsed.

4. (Previously Presented) A method of etching a structure into an etching body using a plasma, comprising:

injecting a first pulse train into the etching body via a substrate electrode; and

injecting a second pulse train into the plasma for modulating a plasma intensity over time, wherein:

the first pulse train has a frequency that differs from a frequency of the second pulse train, and

a fixed, integral ratio exists between the frequency of the first pulse train and the frequency of the second pulse train.

5. (Original) The method as recited in Claim 4, wherein:

the etching body includes a silicon body,

the structure is a recess in the silicon body that is laterally defined in a precise manner by an etching mask, using the plasma,

a high-frequency pulsed, low-frequency modulated high-frequency power is injected at least temporarily into the etching body via a high-frequency AC voltage, using the substrate electrode, and  
the plasma is modulated in its intensity as a function of time.

6. (Original) The method as recited in Claim 5,  
wherein: the plasma is pulsed.

7. (Previously Presented) A method of etching a structure into an etching body using a plasma, comprising: performing a first pulsing of the plasma at a frequency of at least 500 Hz, wherein:

the etching body includes a silicon body,  
the structure is a recess in the silicon body that is laterally defined in a precise manner by an etching mask, using the plasma,  
a high-frequency pulsed, low-frequency modulated high-frequency power is injected at least temporarily into the etching body via a high-frequency AC voltage, using a substrate electrode, and  
the plasma is modulated in its intensity as a function of time.

8. (Previously Presented) The method as recited in Claim 7, wherein:  
the first pulsing of the plasma is at a frequency of 1 kHz to 10 kHz.

Claim 9. (Canceled).

10. (Previously Presented) The method as recited in Claim 7, further comprising:

performing a low-frequency pulsing of the high-frequency pulsed, low-frequency modulated high-frequency power, wherein:

the first pulsing of the plasma and the low-frequency pulsing of the high-frequency pulsed, low-frequency modulated high-frequency power are performed at the same frequency and with a fixed phase ratio between the first pulsing and the low-frequency pulsing in such a way that a plasma pulse pause

occurs during a pause between low-frequency pulses of the low-frequency pulsing.

11. (Original) A method of etching a structure into an etching body using a plasma, comprising:

at least at one time at which an at least approximately ambipolar plasma is present, adding to the plasma an inert gas that is at least one of light and easily ionizable.

12. (Original) The method as recited in claim 11,

wherein: the inert gas includes helium.

13. (Original) The method as recited in Claim 12, wherein:

the helium is added at least at one point in time at which no high-frequency power is being injected into the etching body via a substrate electrode.

14. (Original) The method as recited in Claim 11, wherein:

the etching body includes a silicon body,

the structure is a recess in the silicon body that is laterally defined in a precise manner by an etching mask, using the plasma,

a high-frequency pulsed, low-frequency modulated high-frequency power is injected at least temporarily into the etching body via a high-frequency AC voltage, using a substrate electrode, and

the plasma is modulated in its intensity as a function of time.

15. (Original) The method as recited in Claim 14,

wherein: the plasma is pulsed.

16. (Original) A method of etching a structure into an etching body using a plasma, comprising:

performing a first modulation of an intensity of the plasma as a function of time;

setting as a plasma pulse frequency an odd-numbered multiple of a frequency of a low-frequency modulation of a high-frequency power injected into the etching body via a substrate electrode; and

synchronizing the first modulation and the low-frequency modulation with one another so that  $n$  plasma pulses ( $n = 1, 2, 3, \dots$ ) fall in each pulse injected into the etching body using the substrate electrode while  $n + 1$  plasma pulses occur during a pause in an energy injection into the etching body.

17. (Original) The method as recited in Claim 16, wherein:

the etching body includes a silicon body,

the structure is a recess in the silicon body that is laterally defined in a precise manner by an etching mask, using the plasma, and

a high-frequency pulsed, low-frequency modulated high-frequency power is injected at least temporarily into the etching body via a high-frequency AC voltage, using the substrate electrode.

18. (Original) The method as recited in Claim 1, wherein:

the structure includes a trench having a high aspect ratio, and

the etching body includes one of a dielectric layer and a dielectric base body.

19. (Original) The method as recited in Claim 1, wherein:

the etching body includes a layer of silicon,

the structure includes a trench having a high aspect ratio,

the trench is introduced into the silicon layer, and

after a production of the trench, at least one of an isotropic underetching and an isotropic, sacrificial-layer etching is performed.

20. (Original) The method as recited in Claim 19, wherein:

the at least one of the isotropic underetching and the isotropic, sacrificial-layer etching is performed using one of fluorine radicals and a highly oxidizing fluorine compound.

21. (Previously Presented) The method as recited in Claim 20, wherein:  
the highly oxidizing fluorine compound includes  $\text{ClF}_3$ .

## **REMARKS**

### **I. Introduction**

Claims 1 to 8 and 10 to 21 are pending in the present application. In view of the following remarks, it is respectfully submitted that all of the presently pending claims are allowable, and reconsideration is respectfully requested.

### **II. Rejection of Claims 1 to 3, 8, and 10 Under 35 U.S.C. § 112, Second Paragraph**

Claims 1 to 3, 8, and 10 were rejected under 35 U.S.C. § 112, second paragraph as allegedly indefinite. It is respectfully submitted that these claims fully comply with the definiteness requirement of 35 U.S.C. § 112, second paragraph for at least the following reasons.

As an initial matter, although the Final Office Action indicates that claims 1 to 3, 8 and 10 are rejected under 35 U.S.C. § 112, second paragraph, there are no grounds of rejection under 35 U.S.C. § 112, second paragraph set forth for claims 8 and 10. Clarification is respectfully requested.

The definiteness requirement of 35 U.S.C. § 112, second paragraph merely requires that "the claims set out and circumscribe a particular subject matter with a **reasonable degree of clarity and particularity.**" M.P.E.P. § 2173.02 (emphasis added). Further,

[d]efiniteness of claim language must be analyzed, not in a vacuum, but in light of:

(A) The content of the particular application disclosure;

(B) The teachings of the prior art; and

(C) The claim interpretation that would be given by one possessing the ordinary level of skill in the pertinent art at the time the invention was made.

*Id.* The present rejection does not appear to take all of these factors into consideration. For example, the present rejection does not appear to consider the content of the application disclosure as presented, *e.g.*, in the Specification.

As regards the assertion at page 3 of the Final Office Action that claim 1 is indefinite because "'approximately' is not positively reciting the presence of the ambipolar plasma, it is firstly noted that claim 1 recites that the plasma is "*at least approximately ambipolar*" (emphasis added). Thus, in view of the proper

considerations set forth above for analyzing the definiteness of claim language, it would be readily apparent to one of ordinary skill in the art that claim 1 includes plasmas having a polarity of zero as well as plasmas having polarities of approximately zero. Indeed, as set forth in the Amendment submitted on September 29, 2009, one of ordinary skill in the art would recognize that the presence of an "at least approximately ambipolar plasma" corresponds to the presence of a plasma having a polarity sufficiently close to zero (see page 6, lines 26 to 31 of the Specification) to the extent that the plasma is capable of causing the undesired effects described at page 7, lines 7 to 11 of the Specification. Thus, the present claims sufficiently set out and circumscribe a particular subject matter with a reasonable degree of clarity and precision, which, as indicated above, is all that is required for compliance with the definiteness requirement of 35 U.S.C. § 112, second paragraph.

In view of all of the foregoing, withdrawal of this rejection is respectfully requested.

**III. Rejection of Claims 1 to 3, 7, 8, and 18 to 20 Under 35 U.S.C. § 103(a)**

Claims 1 to 3, 7, 8, and 18 to 20 were rejected under 35 U.S.C. § 103(a) as unpatentable over the combination of U.S. Patent No. 6,143,476 ("Ye et al."), "Charge-free etching process using positive and negative ions in pulse-time modulated electron cyclotron resonance plasma with low-frequency bias" ("Ohtake et al."), and U.S. Patent Application Publication No. 2003/0070759 ("Aota et al."). It is respectfully submitted that the combination of Ye et al., Ohtake et al., and Aota et al. does not render unpatentable these claims for at least the following reasons.

Referring to Ye et al., the Examiner continues to assert, at page 4 of the Final Office Action, that "pulsing the plasma generator reads on the limitation of refraining from injecting the high-frequency into the substrate---- in response to an at least approximately ambipolar plasma being present" (emphasis in original). As previously set forth in the Amendment submitted on September 29, 2009, claim 1 plainly recites refraining from injecting the high-frequency power into the etching body via the substrate electrode. As with the Office Action dated June 5, 2009, the Final Office Action does not address this claimed feature. It is, of course, well settled that "[a]ll words in a claim must be considered in judging the patentability of that claim



against the prior art." *In re Wilson*, 424 F.2d 1382, 1385, 165 U.S.P.Q. 494, 496 (C.C.P.A. 1970); M.P.E.P. § 2143.03.

As set forth in the Amendment submitted on September 29, 2009, it is plainly apparent that pulsing a plasma generator is not the same as refraining from injecting a high-frequency power into an etching body via a substrate electrode. Indeed, Ye et al. does not disclose, or even suggest, refraining from injecting a high-frequency power into the etching body via a substrate electrode in response to an at least approximately ambipolar plasma being present, as recited in claim 1.

Regarding the alleged presence of an ambipolar plasma in Ye et al., the Examiner relies on the Ohtake et al. as allegedly defining ambipolar as used in the present claims. However, as previously set forth in the Amendment submitted on September 29, 2009, even if it is assumed, *arguendo*, that the Examiner's interpretation of Ohtake et al. is accurate (which Applicants do not concede), the Examiner's proposed definition would still be improper, since the pending claims must be given their broadest reasonable interpretation consistent with the specification. *In re Weiss*, 989 F.2d 1202, 26 U.S.P.Q. 2d 1885 (Fed. Cir. 1993). The broad interpretation may not expand the meaning of the claim beyond that which was intended by the inventor as set forth in the specification. *Id.* In addition, the words of a claim must be given their plain meaning, unless the plain meaning is inconsistent with the specification. *In re Zletz*, 893 F.2d 319, 321 (Fed. Cir. 1989). In this regard, it is readily apparent that the Examiner's proposed interpretation of the claimed term "ambipolar" is inconsistent with the Specification. See, e.g., page 6, lines 26 to 31 of the Specification.

As set forth in the Specification, the ambipolar state of the plasma depends on the plasma's polarity, *i.e.*, the normalized asymmetry of the masses of the positive and negative charge carriers. See, e.g., page 6, lines 26 to 31 of the Specification. As regards the Examiner's reliance on column 7, lines 21 to 25 of Ye et al. as disclosing (in view of Ohtake et al.) an ambipolar plasma, Ye et al. only mentions an equal number of positive and negative charges without disclosing the relative masses of the positive and negative charge carriers. In this regard, Ye et al. does not disclose any state of a plasma that is ambipolar. Aota et al. also does not disclose any state of a plasma that is ambipolar.

Given that neither Ye et al. nor Aota et al. discloses an ambipolar state of a plasma, it is plainly apparent that the combination of Ye et al. and Aota et al.

does not disclose, or even suggest, refraining from injecting a high-frequency power into the etching body via a substrate electrode in response to an at least approximately ambipolar plasma being present. Ohtake et al. does not cure this deficiency.

Regarding claim 7, as previously set forth in the Amendment submitted on September 29, 2009, even if it is assumed, *arguendo*, that Aota et al. discloses low-frequency modulation of a high-frequency power (which Applicants do not concede), Aota et al. plainly fails to disclose, or even suggest, high-frequency pulsing of a high frequency power. Thus, Aota et al. does not disclose, or even suggest, that a high-frequency pulsed, low-frequency modulated high-frequency power is injected at least temporarily into an etching body via a high-frequency AC voltage, using a substrate electrode. Ye et al. and Ohtake et al. do not cure this deficiency.

In view of the foregoing, it is respectfully submitted that the combination of Ye et al., Ohtake et al., and Aota et al. does not render unpatentable either of claims 1 and 7, or any claim that ultimately depends from either of claims 1 and 7. Accordingly, withdrawal of this rejection is respectfully requested.

#### **IV. Rejection of Claims 4 to 6 and 10 Under 35 U.S.C. § 103(a)**

Claims 4 to 6 and 10 were rejected under 35 U.S.C. § 103(a) as unpatentable over the combination of Ye et al., Ohtake et al., Aota et al., U.S. Patent No. 6,218,196 ("Ise et al."), and U.S. Patent No. 5,779,925 ("Hashimoto et al."). It is respectfully submitted that the combination of Ye et al., Ohtake et al., Aota et al., Ise et al., and Hashimoto et al. does not render unpatentable these claims for at least the following reasons.

Initially, Applicants note that claim 4 was amended in the Amendment submitted on September 29, 2009 to plainly recite that the first pulse train has a frequency that differs from a frequency of the second pulse train. Despite the presence of this limitation in claim 4, the rejection of claims 4 to 6 and 10 as set forth in the Office Action of June 5, 2009 appears to be re-presented in the Final Office Action *verbatim*, again alleging at page 6 of the Final Office Action that "[a]s the claims do not limit that the first and second or the low-frequency pulses are different from each other, it is considered that the low frequency pulse falls within the claimed range and expected to have the similar result." Thus, it is plainly apparent that the present

rejection fails to consider all of the limitations of the present claims, as it must, in analyzing patentability of the claims against the prior art. See *In re Wilson*, 424 F.2d 1382, 1385, 165 U.S.P.Q. 494, 496 (C.C.P.A. 1970) and M.P.E.P. § 2143.03. Thus, the present rejection is deficient for at least this reason. Moreover, the present rejection is also deficient for at least the additional reason that, as set forth below and in the Amendment submitted on September 29, 2009, the proposed combination and/or modification of Ye et al., Ohtake et al., Aota et al. fails to disclose, or even suggest, all of the features of the present claims.

Claim 4, directed to a method of etching a structure into an etching body using a plasma, requires, *inter alia*, a fixed, integral phase ratio between a first pulse train injected into an etching body and a second pulse train injected into a plasma. Claim 4 also recites that the first pulse train has a frequency that differs from a frequency of the second pulse train, and that a fixed, integral ratio exists between the frequency of the first pulse train and the frequency of the second pulse train.

The present rejection relies on the alleged disclosure of Ise et al. of a duty ratio of 50% as constituting the fixed, integral ratio recited in claim 4. Ise et al. discloses a pair of electrodes with a single pulse train. See col. 2, lines 26 to 55. The duty ratio refers to the relative duration of the discharge or "on" period with respect to the total of the discharge period and suspension, or "off." period. See Ise et al. at col. 5, lines 36 to 42. For example, where the discharge period is equal to the suspension period, the duty ratio would be 50%, *i.e.*, the discharge period would be half of the total of the discharge and suspension periods.

As indicated above, claim 4 recites a fixed, integral ratio between a frequency of a first pulse train and a frequency of a second pulse train. In this regard, the duty ratio disclosed in Ise et al. plainly does not constitute a ratio between frequencies of a first pulse train and second pulse train.

Regarding the assertion at page 6 of the Final Office Action that "the claims do not limit that the first and the second or the low-frequency pulses are different from each other, as set forth above, claim 4 plainly indicates that that the first and second pulse trains are not one and the same.

The Final Office Action further relies on the disclosure of Hashimoto et al. as allegedly disclosing the ratio recited in claim 4. In this regard, Hashimoto et al. discloses signals having the same frequency. See, *e.g.*, col. 10, lines 7 to 15. In this regard, Hashimoto et al. does not disclose, or even suggest, a first pulse train

that has a frequency that differs from a frequency of the second pulse train, wherein a fixed, integral ratio exists between the frequency of the first pulse train and the frequency of the second pulse train.

As indicated above, neither of Ise et al. and Hashimoto et al. discloses, or even suggests, a first pulse train that has a frequency that differs from a frequency of the second pulse train, wherein a fixed, integral ratio exists between the frequency of the first pulse train and the frequency of the second pulse train. Ye et al., Ohtake et al., and Aota et al. also do not disclose, or even suggest, this feature. As such, the combination of Ye et al. Ohtake et al., Aota et al., Ise et al., and Hashimoto et al. does not disclose all of the features of claim 4 and therefore does not render unpatentable claim 4 or any claim that ultimately depends from claim 4.

Claim 10 depends from claim 7 and therefore includes all of the features of claim 7. As indicated above, the combination of Ye et al., Ohtake et al., and Aota et al. does not render unpatentable claim 7. Ise et al. and Hashimoto et al. do not cure the deficiencies of the combination of Ye et al., Ohtake et al., and Aota et al. As such, it is respectfully submitted that the combination of Ye et al., Ohtake et al., Aota et al., Ise et al., and Hashimoto et al. does not render unpatentable dependent claim 10.

In view of all of the foregoing, withdrawal of this rejection is respectfully requested.

**V. Rejection of Claims 11 to 15 Under 35 U.S.C. § 103(a)**

Claims 11 to 15 were rejected under 35 U.S.C. § 103(a) as unpatentable over the combination of Ye et al., Ohtake et al., and U.S. Patent No. 5,290,383 ("Koshimizu"). It is respectfully submitted that the combination of Ye et al., Ohtake et al., and Koshimizu does not render unpatentable these claims for at least the following reasons.

Nowhere does the combination of Ye et al., Ohtake et al. and Koshimizu. disclose, or even suggest, **at least at one time at which an at least approximately ambipolar plasma is present**, adding to the plasma an inert gas that is at least one of light and easily ionizable, as required by independent claim 11. The Final Office Action at page 7 continues to refer to col. 14, lines 29 to 41 of Koshimizu, which states that certain gases are introduced into the etching chamber prior to application of power to the electrodes 106 and 108. However, as Applicants

previously set forth in the Amendment submitted on September 29, 2009, the Response submitted on December 12, 2007, the Amendment submitted on June 11, 2008, the Amendment submitted on December 11, 2008, and the "Reply Under 37 C.F.R. § 1.116" submitted on May 22, 2009, Koshimizu does not state that these gases are introduced at a time when at least approximately ambipolar plasma is present in the chamber. To the contrary, in Koshimizu the **gases are introduced even before generation of the plasma in the chamber.** See col. 14, lines 43 to 47.

As indicated above, the combination of Ye et al., Ohtake et al., and Koshimizu does not disclose, or even suggest, all of the features of independent claim 11. As such, it is respectfully submitted that the combination of Ye et al., Ohtake et al., and Koshimizu does not render unpatentable claim 11.

Claims 12 to 15 ultimately depend from claim 11 and therefore include all of the features recited in claim 11. As such, it is respectfully submitted that the combination of Ye et al., Ohtake et al., and Koshimizu does not render unpatentable these dependent claims for at least the same reasons set forth above in support of the patentability of claim 11.

In view of all of the foregoing, withdrawal of this rejection is respectfully requested.

#### **VI. Rejection of Claims 16 and 17 Under 35 U.S.C. § 103(a)**

Claims 16 and 17 were rejected under 35 U.S.C. § 103(a) as unpatentable over the combination of Ye et al., Ohtake et al., and U.S. Patent Application Publication No. 2002/0114897 ("Sumiya et al."). It is respectfully submitted that the combination of Ye et al., Ohtake et al., and Sumiya et al. does not render unpatentable these claims for at least the following reasons.

As previously set forth in the Amendment submitted on September 29, 2006, the combination of Ye et al., Ohtake et al., and Sumiya et al. fails to disclose, or even suggest, the specific relationship between the plasma pulse frequency and the power injected into the etching body required by independent claim 16, *i.e.*, **setting as a plasma pulse frequency an odd-numbered multiple of a frequency of a low-frequency modulation of a high-frequency power injected into the etching body via a substrate electrode**, and **synchronizing the first modulation and the low-frequency modulation with one another so that n plasma pulses (n**

**= 1, 2, 3, ...) fall in each pulse injected into the etching body using the substrate electrode while  $n + 1$  plasma pulses occur during a pause in an energy injection into the etching body.**

The arguments presented at pages 7 to 8 of the Final Office Action, even if assumed, *arguendo*, to be true (which Applicants do not concede), still would not lead to the specific relationship set forth in claim 16. To the extent that the arguments at pages 7 to 8 of the Final Office Action are understandable, it is apparent that the Examiner treats claim 16 as only disclosing general synchronization and modulation. In this regard, it is again noted that **all words in a claim must be considered in judging the patentability of that claim against the prior art**. *In re Wilson*, 424 F.2d 1382, 1385, 165 U.S.P.Q. 494, 496 (C.C.P.A. 1970); M.P.E.P. § 2143.03.

As indicated above, the combination of Ye et al., Ohtake et al., and Sumiya et al. does not disclose, or even suggest, all of the features recited in claim 16. As such, the combination of Ye et al., Ohtake et al., and Sumiya et al. do not render unpatentable independent claim 16.

Claim 17 depends from claim 16 and therefore includes all of the features recited in claim 16. As such, it is respectfully submitted that the combination of Ye et al., Ohtake et al., and Sumiya et al. does not render unpatentable claim 17 for at least the same reasons set forth above in support of the patentability of claim 16.

In view of all of the foregoing, withdrawal of this rejection is respectfully requested.

#### **VII. Rejection of Claim 21 Under 35 U.S.C. § 103(a)**

Claim 21 was rejected under 35 U.S.C. § 103(a) as unpatentable over the combination of Ye et al., Ohtake et al., and U.S. Patent No. 4,799,991 ("Dockrey"). Applicants respectfully submit that the combination of Ye et al., Ohtake et al., and Dockrey does not render unpatentable claim 21 for at least the same reasons submitted above in support of the patentability of claim 1, from which claim 21 depends. Specifically, Applicants respectfully submit that the combination of Ye et al., Ohtake et al., and Dockrey does not disclose, or even suggest, **refraining from injecting a high-frequency power into the etching body via a substrate electrode in response to an at least approximately ambipolar plasma being**

**present**, as required by claim 1. Dockrey purportedly relates to a process for differentially etching polycrystalline silicon. Dockrey does not remedy the above-noted deficiencies of the combination of Ye et al. and Ohtake et al. Nor is Dockrey relied upon for remedying the above-noted deficiencies of the combination of Ye et al. and Ohtake et al. Accordingly, withdrawal of the present rejection is respectfully requested.

**VIII. Conclusion**

It is therefore respectfully submitted that all of the presently pending claims are allowable. All issues raised by the Examiner having been addressed, an early and favorable action on the merits is earnestly solicited.

Respectfully submitted,

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